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STUDY OF ABRASIVE CERAMIC POWDERS ON THE FINE POLISHING OF METALLIC AND POLYMERIC SURFACES

Landsberger, F.O.O.[1,a]; Couto, A.A.[2,3,b]; Zandonadi, A.R.[3,c]; Reis, D.A.P.[4,d]

[1]Micro Service, Diadema, SP, Brazil
[2]Instituto de Pesquisas Energéticas e Nucleares (IPEN), São Paulo, SP, Brazil
[3]Universidade Presbiteriana Mackenzie, São Paulo, SP, Brazil
[4]Instituto Tecnológico de Aeronáutica, São José dos Campos, SP, Brazil
[a]felipe.ortega@uol.com.br, [b]acouto@ipen.br, [c]arzandonadi@mackenzie.br, [d]danielireis@hotmail.com

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Abstract: Nowadays the polishing products for finishing procedures have a high cost in the finishing process, once these products are imported or made by synthetic diamond. This study shows the polishing effects of several of low cost abrasives ceramic powders available on the national market. The material used in this study were silicon carbide and aluminum oxide, the variables of particle diameter and surface roughness were analyzed. The test samples materials used in the experiments were aluminum, carbon steel 1020, stainless steel 304 and polycarbonate. Finally, a comparative evaluation was showed using metallographic polishers already existent on the market.

Introduction

The stage of the aluminum oxide synthesis powder was carried through by the Nova Bandeirante Chemical Products Ltda company, where it was synthesized and supplied with a chemical composition of 99.01% of purity and particle size of 0.52% retained 325 mesh. However this material presents an improper particle size distribution to be used in the polishing market, thus being, it was made necessary an improvement of the particle size distribution of the product. The improvement was carried through by the Micro Service Chemical Industry Ltda. that is specialized in industrial process services, between them, micronization and aero-classification. After the improvement the product are classified by the name Calcined Alumina MS 3000 that presents particles with average diameter of 1.26 micrometers and maximum diameter of 8 micrometers and Calcined Alumina MS 500 that presents particles with average diameter of 4.36 micrometers and maximum diameter of 30 micrometers.

The stage of silicon carbide powder synthesis was carried through by the company Saint-Gobain Material Ceramic Ltda., where it was synthesized and supplied with a chemical composition of 98.26% of purity and particle size of 16.8% retained on 400 mesh, 39.4% retained on mesh 325, 3.5% retained on 200 mesh, 1.7% retained on 170 mesh and 0.3% on 140 mesh. However this material presents an improper particle size distribution to be used in the polishing market, thus being, it was made necessary an improvement of the particle size distribution of the product. After the improvement the product are classified by the name Silicon Carbide ABR MS 4000 that presents particles with average diameter of 0.8 micrometers and maximum diameter of 6 micrometers, Silicon Carbide ABR MS 2000 presents particles with average diameter of 2.8 micrometers and maximum diameter of 15 micrometers, and Silicon Carbide ABR MS 400 that presents particles with average diameter of 13 micrometers and maximum diameter of 36 micrometers.

This work was based on the study of the effect on the polishing with several types of advanced ceramic powders, with high abrasiveness properties, tested on surfaces composed by metallic and polymeric material. Using already existed standardized test methods, it was desired to achieve a surface exempt of imperfections and adequate for utilization. Finally, the terms lapping and fine polishing are very known, however its concept is more known in qualitative terms, that is evident for the fact that industries still continue to specify like rustic, smooth, cloudy, shining or with an adimensional number the finished polished surface. None of these terms are sufficient precise and tends to different meanings depending of the observer point of view. Thus being, this work supplies quantitative values on the lapping stage and final polishing.

Experimental Procedure

The tested samples for the polishing experiments were obtained from metallic bars and convex plates of polymeric material. The metallic bars are composed of a commercial aluminum alloy, a commercial 304 stainless steel alloy and commercial 1020 carbon steel alloy, where all have a 30 mm diameter and a 300 mm length. For the polymeric material experiments it was used a convex sample plate of polycarbonate with 6 cm of diameter and 5 mm of thickness. The polycarbonate was supplied by the company Industrial Mello Ltda., who produces ophthalmologic lenses and uses an imported ceramic powder for polishing. The polycarbonate presents amorphous structure and must promote a low refractive index after the polishing. The polishing solution is a ceramic suspension formed by three components, dispersant, solvent and ceramic powder. The main characteristics of a ceramic powder that influence the preparation of a suspension are: the particle size distribution and the physical-chemical properties of the powder surface [1-3]

For comparison of the final polishing with the formulated solutions in this work, a metallographic polisher solution based on aluminum oxide was used, being identified as SOLUTION A and formulated according the recommended procedures from the manufacturer. The polishing paste AP-PASTE, brand STRUERS, containing aluminum oxide was diluted in 20% and 80% of distilled water. The pH value of the solution was 3.5. In following, solutions had been prepared with Calcined Alumina from Micro Service Company in different particle sizes. Identified as SOLUTION B the formulation with Calcined Alumina MS 3000, in a ratio of 20% of Calcined Alumina MS 3000, 80% of distilled water and 0.4 g of hydrochloric acid, resulting in pH value of 3,7. Identified as SOLUTION C formulation with Calcined Alumina MS 500, in the ratio of 5% of Calcined Alumina MS 500, 95% of distilled water and 0.4 g of hydrochloric acid, resulting in pH value of 4 [4-10].

Using the same preparation procedure carried through with aluminum oxide, a comparison solution was formulated based on synthetic diamond in accordance with the metallographic information from the manufacturer and being used as comparison between the formulated solutions in this work. This comparison solution was identified as SOLUTION D, where the synthetic diamond of type PD-1 of brand AROTEC was added in a ratio of 10% and ethylic alcohol on a ratio of 90%. In following, solutions had been prepared with Silicon Carbide from Micro Service Company in different particle sizes. Identified as SOLUTION E, the formulation with Silicon Carbide MS 4000, in a ratio of 20%, 80% of distilled water and 0.4 g of sodium hydroxide, resulted in a pH value of 9. The pH value for a water suspension of Silicon Carbide must be above of 8.5 and below of 11,5 providing a suspension with low agglomeration of particles. SOLUTION F was formulated with Silicon Carbide ABR MS 400, in a ratio of 5%, 95% of distilled water and 0.01 of Disperlan (defloculant based on ammonium polyacrylate), resulting in a pH value of 8.7 [11].

For standardization and trustworthiness in the acquired data and final results, it makes necessary a control of the roughness of the samples surfaces from the beginning to the ending of the lapping. The aluminum, carbon steel and staineless steel samples were prepared and the procedures of lapping was carried through with sandpapers in meshes 240, 320, 400 and 600 and the lapping of the polycarbonate sample was carried through with the sandpaper in mesh 600. The averages of the Ra roughness values had been calculated measuring three points on sample surface [8,10].

The polishing experiments of the test samples were carried through with the chosen of the ceramic powder solution and the adequacy of the polishing machine parameters: rotation speed of the polishing disc; mass applied on the test sample; polishing time and addition flow of polisher solution over the polishing disc.

Results

Table 1 shows the results of the Ra roughness averages after the lapping of the samples in meshes 240, 320, 400 and 600.

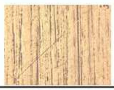
Table 1 - Average values of the Ra roughness after the lapping in mesh 600.

Ra roughness after the lapping of the samples in mesh 600				
Sample	Carbon Steel 1020 [μm]	Stainless Steel 304 [μm]	Aluminium [μm]	Polycarb. [μm]
1	0.19	0.19	0.26	0.83
2	0.20	0.18	0.30	0.78
3	0.19	0.20	0.28	0.80
4	0.21	0.20	0.27	
5	0.19	0.19	0.26	
6	0.20	0.19	0.25	
7	0.19	0.19	0.29	
8	0.19	0.19	0.27	
9	0.20	0.19	0.30	
10	0.19	0.19	0.32	

It was verified that the aluminum samples presented a higher roughness due the lower hardness of the material. The results of the Polycarbonate average Ra roughness after the lapping in mesh 600. It showed that the abrasive sandpaper grains of mesh 600 are excessively harder than the surface of the polycarbonate. It promotes deep scratches risks on its surface. It was also verified the dispersion of the Ra roughness values after the mesh 600 lapping for each material. The objective was to get an equal reduction of the dispersion on the Ra roughness on every sample after every sandpaper lapping. The analysis of the dispersion was not carried through for the polycarbonate samples.

Table 2 shows the polisher solutions parameters to preparation of metallic and polymeric surfaces.

Table 2 – Polisher solutions parameters to preparation of metallic and polymeric surfaces.

Solution	Sample	Disc speed	Mass	Solution flow	Time (min.)	Average Roughness Ra	Average Roughness Rz	Surface Image
COMPARISON (imported polisher)	**Aluminum**	**300 rpm**	**0,55 Kg**	**5 drops/ 2 sec.**	**5**	**0,10 µm**	**0,41 µm**	
Al_2O_3 type MS 500 (SOL. C)	**Aluminum**	**300 rpm**	**0,55 Kg**	**1 drop/ 2 sec.**	**10**	**0,06 µm**	**0,26 µm**	
COMPARISON (diamond)	**Stainless Steel 304**	**300 rpm**	**0,55 Kg**	**1 drop/ 2 sec.**	**10**	**0,08 µm**	**0,24 µm**	
SiC type ABR MS 400 (SOL. F)	**Stainless Steel 304**	**300 rpm**	**0,55 Kg**	**1 drop/ 2 sec.**	**10**	**0,07 µm**	**0,28 µm**	
COMPARISON (diamond)	**Carbon Steel 1020**	**300 rpm**	**0,55 Kg**	**1 drop/ 2 sec.**	**10**	**0,03 µm**	**0,37 µm**	
SiC type ABR MS 400 (SOL. F)	**Carbon Steel 1020**	**300 rpm**	**0,55 Kg**	**1 drop/ 2 sec.**	**10**	**0,07 µm**	**0,36 µm**	
COMPARISON (diamond)	**Polycarb.**	**300 rpm**	**0,55 Kg**	**1 drop/ 2 sec.**	**10**	**0,49 µm**	**2,74 µm**	
Al_2O_3 type MS 500 (SOL. C)	**Polycarb.**	**300 rpm**	**0,55 Kg**	**1 drop/ 2 sec.**	**10**	**0,16 µm**	**1,08 µm**	
SiC type ABR MS 4000 (SOL. E)	**Polycarb.**	**300 rpm**	**0,55 Kg**	**1 drop/ 2 sec.**	**10**	**0,15 µm**	**1,10 µm**	

On agreement with the experimental results it concluded that in the stage of lapping is was possible to obtain quantitative values of the average Ra roughness. The Aluminum resulted Ra roughness of 0.20 µm with maximum deviation of ± 1 µm. Stainless Steel 304 of 0.19 µm with maximum deviation of ± 1 µm and Carbon Steel 1020 of 0.285 µm with maximum deviation of ±3.5 µm.

In the polishing stage it was possible to conclude that the Aluminum samples were more difficulty to polish, presenting particle agglomeration of the polisher solution on its surface and appearance of scratches due the lower hardness of the material and higher hardness and particle size of the ceramic powder. On the Aluminum sample experiment the best polisher solutions was SOLUTION C. made of Calcined Alumina MS 500. It promoted a surface with lower agglomeration. But there's still was a great amount of scratches on the surface.

Conclusions

It was possible to verify that for Stainless Steel 304 the best polisher solution was SOLUTION F made of Silicon Carbide ABR MS 400. It promoted a surface with very low roughness and practically exempt of particle accumulations. For the Carbon Steel 1020 the best polisher solution was SOLUTION F made of Silicon Carbide ABR MS 400 where it promoted a surface practically exempt of particle accumulations. Finally the polycarbonate presented a reduction of its roughness after the polishing using SOLUTIONS B and E. It was insufficient for the application on the ophthalmologic market where polished polycarbonate is used.

In relation to the polishing process, one concludes that the polisher flow mass force and polishing time are essential for a good polishing result. However the method and the equipment used in this process had not been adequate for the polycarbonate polishing.

Finally this study were able to demonstrate the possibility to nationalize polishing products mainly polishers used on large scale applications, where large amounts are consumed and represents a significant percent on the process cost and final product value.

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